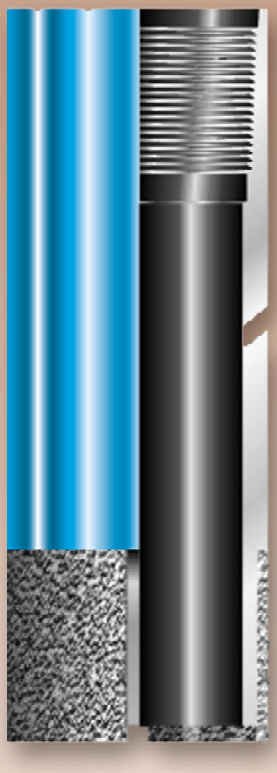
ITCOLOY AND MILLING TOOLS

Instruction Manual 5100



Itcoloy and Milling Tools

NATIONAL OILWELL VARCO

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The designs and specifications for the tools described in this instruction manual were in effect at the time this manual was approved for printing. National Oilwell Varco, whose policy is one of continuous improvement, reserves the right to discontinue models at any time, or to change designs and specifications without notice or without incurring obligation.

Fifteenth Printing, September 2005

General Description

Bowen Itcoloy is a special hardfacing material made of crushed sintered tungsten carbide particles compounded with a resilient matrix of nickel-silver alloy. Bowen Itcoloy is made in rod form for convenience of application wherever oxygen acetylene welding equipment is available.

In oilwell milling, when an Itcoloy hardfaced tool is rotated and lowered against an object (that is, a fish, cement or formation), a multiplicity of small tungsten carbide particles imbed themselves into the object. Each tungsten carbide particle develops a small chip along the edge as it is moved across the object, cutting the object. As a particle's cutting edge becomes dulled, pressures and strains increase within the particle, causing a fracture to occur. Such fractures then create new cutting edges along the fracture plane. This process is repeated with each tungsten carbide particle, continuously renewing the cutting edges until the entire content of tungsten carbide particles is exhausted.

Tungsten carbide particles, with a hardness nearly that of diamonds, retain their hardness at high temperatures and are not affected by the heat generated from the cutting operation. The tough, resilient, nickel-silver alloy matrix securely holds the tungsten carbide particles in place and cushions the particles against severe impact.

A macro-photograph of a portion of an Itcoloy Rod showing the concentration of tungsten carbide particles imbedded in the nickel-silver alloy matrix.

Use of Itcoloy

Bowen Itcoloy is used to form the cutting or milling surfaces on milling shoes, rotary shoes, junk mills, section mills, milling stabilizers, piloted liner mills, or any tool that may be subjected to high abrasive wear and severe impact.

Tools dressed with Itcoloy are used to mill away all kinds of junk, including drill pipe, drill collars, bits, cones, casing, liners, and liner hangers. This advancement in metallurgy — which suspends fragmented tungsten carbide particles in a resilient matrix — provides milling tools requiring minimum torque, that have high-speed cutting ability, and that have increased life or wearing ability.

Construction of Itcoloy Rod

Bowen Itcoloy consists of selected grades of crushed sintered tungsten carbide particles imbedded in a resilient nickel-silver alloy matrix.

Itcoloy uses only the hardest steel cutting sintered carbides. The sintered tungsten carbides are crushed, then sifted and graded to appropriate screen mesh sizes. After screening, each particle is hand selected to assure sharp, full bodied particles and to eliminate all slivers and splinters that may have passed through the screen mesh.

After screening and grading, the crushed sintered tungsten carbide particles are made into a rod form with a maximum concentration of particles imbedded in a matrix of nickel-silver alloy that holds the particles in suspension. The matrix material has an ultimate shear strength of 100,000 psi.

Bowen Itcoloy is made in rod form so that it may be applied in the field or any shop wherever oxygen acetylene welding equipment is available. For best application, described later in the text, Bowen recommends the use of Bowen Brazing Flux and Bowen Tinning Rod.

Milling Shoes and Rotary Shoes

Bowen Milling Shoes or **Bowen Rotary Shoes** are designed in various sizes and styles to meet the various conditions encountered in oil well fishing and washover operations. Illustrated herein are many of the styles with an explanation of their intended service.

Overshot Milling Shoe is used to mill away jagged metal from the top of the fish so that the fish will pass easily into the Overshot Bowl.

Packet Retriever Milling Shoe is used to mill away the slips of a production packer without damage to the casing so that the remainder of the packer can be retrieved.

Junk Basket Milling Shoe is used to mill away jagged edges from small junk or bit cones so that the junk will pass into the basket and be retrieved, or for formation cutting to cut small cores.

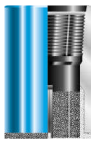
Type A Rotary Shoe is used to cut metal on the fish without cutting the casing. Cuts on the inside diameter and the bottom. Does not cut on the outside diameter.

Type B Rotary Shoe is used for washing over a fish and cutting metal or formation in the open hole. Cuts on the outside diameter and the bottom. Does not cut on the inside diameter.

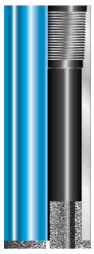
Type C Rotary Shoe is used for washing over and cutting metal, formation or cement. Cuts freely on the inside diameter, the outside diameter, and the bottom.

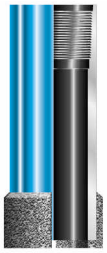
Type D Rotary Shoe is used to cut metal on the fish without cutting the casing where clearances are limited. Cuts on the inside diameter, and the bottom. Does not cut on the outside diameter.

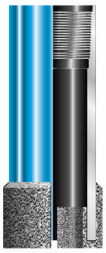

Overshot Milling Shoe

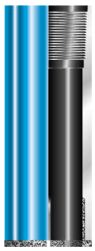

Packer Retriever Milling Shoe


Junk Basket Milling Shoe


Type A Rotary Shoe


Type B Rotary Shoe


Type C Rotary Shoe


Type D Rotary Shoe

Type E Rotary Shoe is used for washing over a fish and cutting metal, formation or cement in the open hole where clearances are limited. Cuts on the outside diameter and the bottom. Does not cut on the inside diameter.

Type G Rotary Shoe is used for washing over and cutting metal, formation or cement in the open hole with limited inside clearances. Cuts on the inside diameter, the outside diameter, and the bottom.

Type H Rotary Shoe is used for washing over and cutting metal in the open hole with limited clearance on the outside diameter. Cuts on the inside diameter, the outside diameter, and the bottom.

Type I Rotary Shoe is used for washing over and cutting formation only. Sawtooth design permits maximum circulation. Cuts on the bottom only. Does not cut on the outside diameter or inside diameter.

Type J Rotary Shoe is used for washing over and cutting formation only. Sawtooth design with side wings permits maximum circulation. Cuts on the bottom and on the outside diameter. Does not cut on the inside diameter.

Type K Rotary Shoe is used for washing over and cutting on the bottom face only. Does not cut on the outside diameter or the inside diameter.

Type F Rotary Shoe is used to size and dress the top of a fish inside the casing. Makes a tapered cut on the inside diameter, and cuts on the bottom. Does not cut on the outside diameter.

Bowen Milling Shoes and Bowen Rotary Shoes hardfaced with Bowen Itcoloy are recommended for all types of washover operations. The increased speed of cutting and penetration makes an Itcoloy hardfaced shoe more economical to use than a conventional hard metal shoe.

Bowen Milling Shoes are used to mill over and free stuck packers, spears, stabilizers, string reamers, rock bits or any metal objects which cannot be removed from the well bore with conventional fishing procedures and fishing tools.

Bowen Rotary Shoes are excellent for washing over stuck pipe to cut away shales, clay, sand, salt, limestone, cement, anhydrite, red beds and other formations.

Graded particle size of Bowen Itcoloy hardfacing for Milling Shoes and Rotary Shoes is determined by the dimensional limitations of the shoe itself, the dimensional limitations of the fish and the well bore, and, finally, the work to be done.

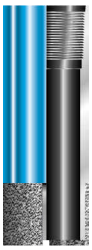
Generally speaking, coarse grades ($^3/_8$" to $^3/_{16}$") of Itcoloy are utilized for metal cutting, and medium grades ($^3/_{16}$" to $^1/_{16}$") are utilized for formation and cement cutting. The fine grades (10–18 mesh), or smaller, are used to prevent abrasive wear on such items as tool joints, stabilizer subs, etc.

Operation of Milling Shoes and Rotary Shoes

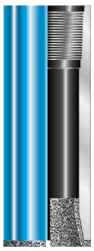
Milling Shoes and Rotary Shoes are used primarily to dress a stuck fish so that a grappling or retrieving tool may engage the fish.

In operation, the penetration rate is affected by the hole condition, the rotary speed, the weight of the drill string upon the milling shoe, the weight and viscosity of the drilling fluid, the dimensional size of the milling shoe, and finally, the size and hardness of the material to be milled. It is apparent from all of these variables that a concise applied weight and revolutions per minute cannot be stated to obtain the most efficient penetration rate expressed in feet per hour.

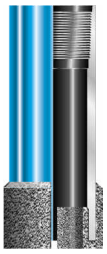
Therefore, the optimum weight and rotary speed must be determined under actual operating conditions. Revolutions per minute (rpm) may vary from 60 rpm to 175 rpm. Washover or milling operations should begin with moderate speed and low weight. Increase both weight and speed until the desired, or optimum, penetration rate is attained.



Type E
Rotary Shoe

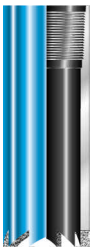


Type F
Rotary Shoe

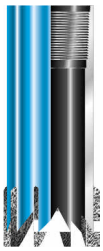


Type G
Rotary Shoe

Type H
Rotary Shoe



Type I
Rotary Shoe



Type J
Rotary Shoe

Type K
Rotary Shoe

Lower the washover string into the well until the milling shoe is a few feet above the top of the fish. Start the pumps and circulate the hole until the top of the fish is clean. Either conventional or reverse circulation may be used. Reverse circulation is often recommended because the velocity of the returns is greater.

Normal pump pressures are recommended with the mud weight and viscosity being sufficient to circulate the cuttings out of the hole. If metal cuttings in great volume are anticipated, which is not usually the case in washover operations, consideration should be given to removing the metal cuttings from the mud stream to prevent damage to the pumping equipment.

The volume and characteristics of the returned cuttings should be checked frequently since they will provide a great deal of information on the washover progress. Metal cuttings being returned will vary in shape and size due to the Itcoloy particle size being used and the material being milled. Chip size is primarily a function of the quality of the steel being milled.

In the event that the penetration rate declines, it is advisable to change the weight or the rotary speed and, in some cases, to spud lightly to re-establish the desired rate of progress.

Milling Tools

Milling tools are designed to mill away a stuck fish that cannot be retrieved by conventional fishing methods.

Since milling is usually a follow-up operation (after several fishing attempts), the fish to be milled away should be familiar to the operator and therefore the selection of the milling tools should be relatively easy to determine, since the dimensional restrictions of the well bore or casing, and the work to be accomplished are known.

The Milling Tool selected should provide maximum exposure of the milling edge to the material to be milled, maximum replacement of the milling edge as wear occurs, and maximum circulation to remove the cuttings. Examples of Milling Tools are described below.

NOTE: Conditions that might make an Itcoloy hardfaced pilot undesirable are when the inside of the pipe to be milled is badly damaged, collapsed or contains junk. An Itcoloy hardfaced pilot is not recommended because of the danger of the pilot "side-tracking" through the damaged pipe. In these cases, it is recommended that a Taper Mill be run to restore the inside diameter of the pipe so that the pilot is free to align the pipe.

Operation of Milling Tools

Bowen Milling Tools are simple to operate. For best results, relatively fast rotary speeds should be available as well as drill collars and drill pipe.

Junk Mills are used to mill away metal objects in the hole that cannot be retrieved with grappling tools or junk baskets.

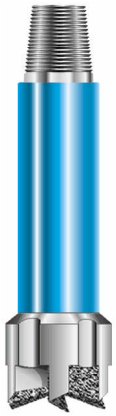
The blade forms of all Junk Mills are designed so that they hold the junk to be milled under the milling face. The mill thus cuts continually rather than sweeping the junk ahead of the blades.

The Junk Mills selected should be 1/8 to 1/4 inch less than the minimum inside diameter of the casing or open hole through which it is to run.

Round Nose Mills are used primarily to mill out the bottom of liners or casing which have been set with a bull plug during original completion. Round Nose Mills cut on the leading edge or nose, along the taper but not the full circumference or periphery of the mill.

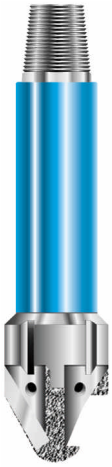
Taper Mills are used primarily to mill out collapsed pipe, to restore elliptical pipe to full bore, and to remove restrictions from the inside diameter such as landing seats, bushings, and any other metal objects that might restrict the well bore. Taper Mills have cutting faces along the taper.

Junk Mill



Junk Mill
with Regular Pin Connection
and Fishing Neck

Round Nose Mill



Round Nose Mill
with Regular Pin Connection
and Fishing Neck

Taper Mill

Taper Mill
with Regular Pin Connection
and Fishing Neck

For maximum results, the mill should be run on the bottom of a string of drill collars weighing any where from 10,000 to 15,000 pounds, depending upon the size (OD) of the mill. Actual weight applied to the mill will necessarily vary due to the size and type of mill, hole condition and depth, and the material to be milled.

The volume and characteristics of the cuttings should be checked frequently since they will provide a great deal of information about the milling progress. The metal cuttings being returned will vary in size and shape due to the Itcoloy particle size and, more importantly, the material being milled. Chip size is primarily a function of the quality of the steel being milled.

High volume pumps will give the best results since high circulation rates will both flush and cool the milling surfaces and circulate the metal cuttings to the surface. The mud weight and viscosity should be adequate to lift the metal cuttings to the surface. A mud viscosity of 50 to 80 centipoises will carry most cuttings to the surface. Consideration should be given to removing the metal cuttings from the mud stream to avoid any damage to the pumping equipment.

With consideration having been given to all of the above, lower the drilling string to within a few feet of the object to be milled. Start the pumps and circulate freely to remove any sand or cuttings before starting to mill.

Rotate with a moderate speed and slowly lower the drill string until the mill makes contact with the object to be milled. Increase rotation and gradually increase weight until the desired or optimum penetration rate is obtained. Suggested speeds are as follows:

OD of Mill	Speed in RPM
3-7/8 to 4-1/4	175
4-3/8 to 4-7/8	150
5 to 5-7/8	125
6 to 6-7/8	100
7 to 7-7/8	90
8 to 8-7/8	80
9 to 9-7/8	75
10 to 10-7/8	70
11 to 11-7/8	65
12 to 12-7/8	60

For ideal penetration rates, it will generally be necessary to try different rotary speeds, weights and pump pressures. Whenever the penetration rate declines, it may be necessary to vary any one or all of these factors to re-establish an efficient penetration rate. Occasional spudding may also help.

Whenever the penetration rate cannot be re-established by varying the factors above or by light spudding, remove the mill from the well, as the Itcoloy hardfacing has probably been worn away.

Maintenance of Milling Tools

All Bowen Milling Tools are of uncomplicated construction and are therefore economical to maintain. They should be cleaned thoroughly after each run, with particular attention to the threads. If the tool is to be stored for a period of time, either paint the surfaces or apply a rust inhibitor. The threads should be coated with a zinc base lubricant.

If the Itcoloy hardfacing has been worn away or is under gauge, it should be built up or restored to full gauge with Itcoloy. This service is available at the Bowen Houston Plant, or it may be applied by a qualified welder wherever oxygen acetylene equipment is available by following the Application procedure.

Application of Itcoloy

To New Tools

Itcoloy tungsten carbide hardfacing is relatively easy to apply. Any qualified welder familiar with brazing techniques can successfully apply Itcoloy by observing the following procedures and precautions.

Oxygen acetylene equipment is used throughout the various stages of the procedure, generally with a low pressure or soft flame. It is best to use a larger tip than is used for welding mild steel. Adjust the torch for a low pressure neutral flame. (A neutral flame is composed of equal parts of oxygen and acetylene.) Heat is localized by working with the blue inner cone close to, but not actually touching, the surface to be hardfaced.

Keep the cone of the flame away from the tungsten carbide particles as much as possible and avoid overheating the working surface. **It is important not to overheat.**

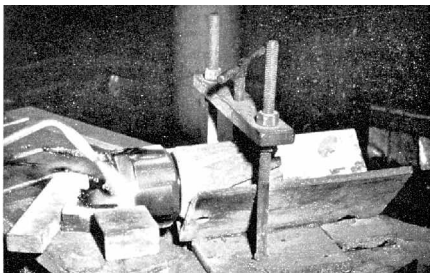
Arrange the working area so that the item to be hardfaced is positioned for downhand welding and secure the item in a suitable turning jig, if possible.

PRECAUTION: Make certain that the working area is well ventilated so that the gases generated during the procedure are carried off and away from the welder. The gases generated are toxic and prolonged inhalation may produce nausea and sickness.

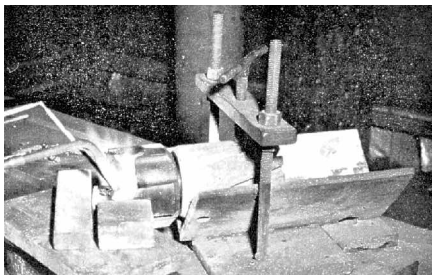
1. Thoroughly clean and brighten the base metal to be hardfaced.
2. Secure the item or tool to be hardfaced in a suitable turning jig and position it for downhand welding. Clamp a carbon mold block in position to define the hardface deposit section or weld a steel rod to the work piece of the diameter or extension required.

For example, if the job is to build a rotary washover shoe with four equally spaced tungsten carbide cutting surfaces 3/16" thick, leaving four equidistant fluid circulation courses, then cut eight equal length 3/16" steel rods and weld these rods to the body to confine and define the tungsten carbide hardfacing. When-ever the required tungsten carbide build-up is relatively small, the carbon mold block or the procedure described above need not be used, as the buildup can be controlled entirely by manipulation of the particles.

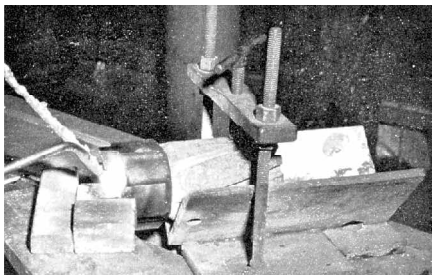
3. Preheat the entire area to be hardfaced as well as the adjacent areas. On small pieces, use the torch heat (neutral flame), playing the flame back and forth over the working area and rotating the piece. Preheat temperatures will vary some what, depending upon the thickness of the metal to be hardfaced. On thin sections the temperature will be 700° to 750°F, while on thicker sections the temperature required will be 900° or more. In brief, the thicker the section, the higher the temperature. Visually, the base metal will be a dull cherry red.



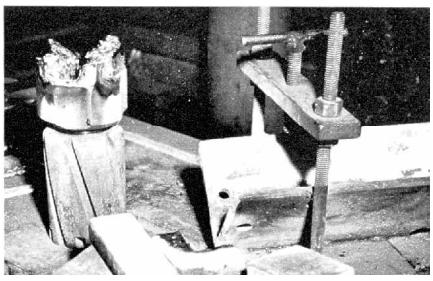
Preheating Junk Mill preparatory to applying Itcoloy. Note carbon block mold shaped to blade form in the lower left corner.



Applying the Bowen Tinning Rod to the Junk Mill. Note that the shaped carbon block is now in position against the Junk Mill.



Applying Bowen Itcoloy to the Junk Mill. The shaped carbon block mold conforms the Itcoloy to the desired shape and buildup.



The Junk Mill has been removed from the fixture and is positioned for finishing the bottom face of the mill with Itcoloy. Note that all of the cutting faces conform to the shape of the carbon block mold.

On larger pieces, it is advisable to have a gas jet directed upon the work piece. This has the advantage of assisting in the preheating procedure and maintaining the work piece at a high temperature, therefore saving the welder considerable time and reducing the amount of oxygen and acetylene consumed.

4. When the work piece is preheated to the proper temperature, apply Bowen Brazing Flux. Use a spoon or spatula to dust or sprinkle the Bowen Brazing Flux over the entire surface to be hardfaced. The Bowen Brazing Flux will bubble and boil if the work piece is properly preheated. Any oxides that may be present on the surface of the base metal or that may be formed during the welding operation will be removed by the Bowen Brazing Flux in the form of fusible slag. Continue preheating until the Flux is clear and fluid.

5. Pick up a Bowen Tinning Rod and, using a soft neutral flame, add the tip of the rod to the puddle of the flux. As the rod melts, the draw of the heat will cause the alloy to flow and follow the heat. Keep the torch in motion. The rate of the travel with the torch should be just as fast as the rod will bond, making sure that the flux is kept on the surfaces. By continually playing the heat of the torch into the base metal, the tinning process will be accomplished quickly and smoothly. When completed, the tinning alloy will measure about 1/16" thick.

NOTE: If the preheat temperature is not sufficient, the molten alloy will not flow smoothly but will form in small balls on the base metal.

Bowen Tinning Rod is a specially compounded nickel-silver brazing alloy particularly suited as a base for Bowen Itcoloy. Bowen Tinning Rod has a working temperature of 1,400° – 1,600° F and produces a corrosion-resistant weld deposit with a hardness of 160-170 Brinell, with a tensile strength of 100,000 psi.

6. Pick up a Bowen Itcoloy Rod and supply to the desired thickness over the tinned surface, keeping the soft neutral flame moving evenly and smoothly over the entire surface. Since Bowen Itcoly is available in a number of graded fragment thicknesses, the desired buildup can usually be made in one pass by using the correct particle size.

For example, if a thickness of 1/4" is desired, use a Bowen Itcoloy Rod containing 1/4" graded tungsten carbide particles.

While the matrix is still molten, the tungsten carbide particles may be positioned. Use a carbon rod to manipulate the particles into the molten matrix — packing, overlapping, and positioning before the matrix solidifies. Proper manipulation during the application will reduce the need for grinding and shaping to size.

If a carbon rod is not available for manipulating the particles, then a tinning rod may be used.

NOTE: Avoid directing the cone of the flame upon the tungsten carbide particles and avoid overheating. Overheating and burning the tungsten carbide particles will result in embrittlement of the particles or the dissolution of some particles, causing them to lose their cutting ability.

7. Upon completion of the hardfacing procedure, set the work piece aside away from drafts to cool slowly. **Do not quench!** It is recommended that the workpiece be covered with an asbestos blanket or wrapped in aluminum foil to retard the cooling process. This will result in a tool with better cutting ability, or high abrasive quality with high impact strength.

8. After the tool has cooled to room temperature, it may be ground to the correct size and shape. Use a coarse grit grinder and rough grind the hardfaced area to the correct I.D., O.D., and shape for the service intended.

9. Clean off the tool, removing all weld spatter, slag, etc., especially noting that the threads are clean. If the tool is to be stored for any length of time before use, either paint the tool or apply a good rust inhibitor.

To Rework Tools

Milling tools, junk mills, rotary shoes, and milling shoes that have been used in hard service in the field can be restored to their original size and usefulness by redressing them with Bowen Itcoloy tungsten carbide hardfacing. It is important to redress such tools to their original size and shape since there is a definite relationship between the tool's size and shape and its intended service.

1. Clean the complete tool thoroughly. Pay particular attention to the threads on the tool because the heat generated during redressing will cause mud to cake and harden in the threads.

2. Using a coarse grinder, rough grind and remove any burrs or irregularities developed from previous use.

3. Examine the tool thoroughly to determine if the base metal or steel support backing has been worn away in previous use. If it has, build up the base metal or steel support with AWS-ASTM E-6010 electrode or equivalent to the diameter orextension required.

Figure a

Figure b

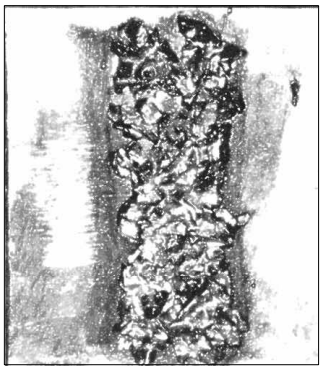


Figure c

Figure d

Unretouched Photographs of Itcoloy Application

NOTE: The base metal or steel blade backing must support the Itcoloy hardfacing to within the fragment size being used. For example, if 1/8" fragment size tungsten carbide hardfacing is to be used, the steel support must be to 1/8" of the finished extension.

4. Apply the Bowen Itcoloy tungsten carbide hardfacing in accordance with the procedure as outlined in the preceding pages.

Itcoloy Application

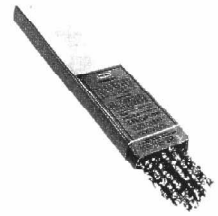
Refer to the unretouched photographs of samples above.

(a) **Correct Application —**This sample shows the correct application at proper heat. The matrix is well bonded to the base metal. The tungsten carbide particles are compactly spaced and securely imbedded in the matrix material. The resulting application, when cool, has a slightly golden hue.

(b) **Improper Application —** This sample shows the result of too much heat. The heat has dissolved the matrix material. The tungsten carbide particles are burned and charred. The resulting application, when cool, has a black and burned appearance.

(c) **Improper Application —** This sample shows the result of too little heat. The matrix is not bonded to the base metal. Although the tungsten carbide particles are imbedded in the matrix, the material will chip and break away from the base metal when milling. The resulting application has a dull silver appearance.

(d) **Improper Application —** This sample shows the result of improper manipulation and spacing of the tungsten carbide particles. Although applied with proper heat and well bonded, large vacancies exist and the result would be an inefficient milling surface. In appearance, the resulting application would have the slightly golden hue as sample (a), but the vacancies or cavities would be very apparent.



Bowen Itcoloy

Bowen Tinning Rod

Bowen Brazing Flux

Bowen Itcoloy, Tinning Rod, and Brazing Flux

Bowen Itcoloy contains the maximum desired concentration of fragmented sintered Tungsten carbides interspersed in a tough resilient matrix. The carbide used are all steel cutting grades with a hardness of 91 to 93 Rockwell "A". The matrix is a special nickel-silver alloy with a tensile strength of 100,000 psi. Bowen Itcoloy is packed in cartons of approximately ten pounds each and is available in the following graded sizes:

Nominal Size	Graded Particle Size	Rod Size	Approximate Weight Per Rod
3/8	3/8" to 1 /4"	3/8" x 3/8" x 18"	14-7/8 oz.
5/16	5/16" to 1/ 4"	5/16" x 5/16" x 18"	12 oz.
3/16	3/16" to 1/8"	1 /4" x 3/16" x 18"	10-5/8 oz.
1/8	1/8" to 1/16"	1/ 4" x 3/16" x 18"	9-1/2 oz.
10 – 18	10 to 18 Screen Mesh	1/ 4" x 3/16" x 18"	7-1/4 oz.
18 – 30	18 to 30 Screen Mesh	3/16" x 3/16" x 18"	5-1/2 oz.
30 – 45	30 to 45 Screen Mesh	3/16" x 3/16" x 18"	5-1/4 oz.

Bowen Rotary Shoe Blanks

No. of Teeth	Connection	Standard OD of Body	Minimum ID of Body	Length	Weight lbs
6	4" F.J.	4"	3-1/4"	16"	18
6	4-1/2" API Casing	5-1/8"	3-3/4"	16"	42
6	4-1/2" F.J.	4-1/2"	3-3/4"	16"	20
6	4-1/2" E.U. or E.L.	4-7/8"	3-3/4"	16"	32
6	4-3/4" API Casing	5-1/2"	4-1/16"	16"	45
6	4-3/4" F.J.	4-3/4"	4-1/16"	16"	28
6	4-3/4" E.U. or E.L.	5-1/8"	4-1/16"	16"	34
6	5" API Casing	5-7/8"	4-3/16"	16"	47
6	5" F.J.	5"	4-3/16"	16"	23
6	5" E.U. or E.L.	5-3/8"	4-3/16"	16"	39
6	5-1/2" API Casing	6-3/8"	4-5/8"	16"	50
6	5-1/2" F.J.	5-1/2"	4-5/8"	16"	30
6	5-1/2" E.U. or E.L.	5-7/8"	4-9/16"	16"	47
6	5-3/4" API Casing	6-5/8"	5"	16"	52
6	5-3/4" F.J.	5-3/4"	5"	16"	26
6	5-3/4" E.U. or E.L.	6-1/8"	5"	16"	30
6	6" API Casing	6-3/4"	5-3/16"	16"	53
6	6" F.J.	6"	5-3/16"	16"	28
6	6" E.U. or E.L.	6-3/8"	5-3/16"	16"	48
6	6-5/8" API Casing	7-1/2"	5-11/16"	16"	70
6	6-5/8" F.J.	6-5/8"	5-11/16"	16"	41
6	6-5/8" E.U. or E.L.	7"	5-5/8"	16"	65
6	7" API Casing	7-7/8"	5-13/16"	16"	75
6	7" F.J.	7"	5-13/16"	16"	47
6	7" E.U. or E.L.	7-1/2"	5-13/16"	16"	72
8	7-5/8" API Casing	8-5/8"	6-5/8"	16"	85
8	7-5/8" F.J.	7-5/8"	6-5/8"	16"	47
8	7-5/8" E.U. or E.L.	8-1/16"	6-9/16"	16"	76
8	8-1/8" API Casing	9-1/8"	7-1/8"	16"	92
8	8-1/8" F.J.	8-1/8"	7-1/8"	16"	50
8	8-5/8" API Casing	9-3/4"	7-1/2"	16"	100
8	8-5/8" F.J.	8-5/8"	7-1/2"	16"	60
8	8-5/8" E.U. or E.L.	9-1/8"	7-7/16"	16"	97
10	9" API Casing	10-1/8"	7-13/16"	16"	120
10	9" F.J.	9"	7-13/16"	16"	56
10	9" E.U. or E.L.	9-1/2"	7-3/4"	16"	78
10	9-5/8" API Casing	10-3/4"	8-1/2"	16"	128
10	9-5/8" F.J.	9-5/8"	8-1/2"	16"	68
10	9-5/8" E.U. or E.L.	10-1/8"	8-7/16"	16"	118
10	10-3/4" API Casing	12"	9-3/4"	16"	140
10	10-3/4" F.J.	10-3/4"	9-3/4"	16"	68
10	11-3/4" F.J.	11-3/4"	10-3/4"	16"	160
10	11-3/4" API Casing	12-7/8"	10-3/4"	16"	160
10	13-3/8" API Casing	14-1/2"	12-1/4"	16"	190
10	16" API Casing	17"	15-1/4"	16"	190

Special Notes:

1. Unless otherwise specified, Shoes will be furnished with same ID as washover string.
2. Any specified ID larger than standard, can be furnished with no additional charge.
3. All Rotary Shoes listed above are available also dressed with crushed tungsten carbide hardfacing.

Bowen Milling Tools

Mill Size (OD)		2-1/4 – 2-1/2	2-5/8 – 2-3/4	2-7/8 – 3-1/8	3-1/4 – 3-5/8	3-1/4 – 4-1/4	4-3/8 – 4-1/2	4-5/8 – 4-3/4	4-7/8 – 5	5-1/8 – 5-1/4	5-3/8 – 5-1/2
Top Connection – Pin		1-13/16 Wilson F.J.	1-1/4 A.P.I. Reg.	1-1/4 A.P.I. Reg.	2-3/8 A.P.I. Reg.	2-3/8 A.P.I. Reg.	2-7/8 A.P.I. Reg.	2-7/8 A.P.I. Reg.	2-7/8 A.P.I. Reg.	3-1/2 A.P.I. Reg.	3-1/2 A.P.I. Reg.
Catalog Standard ‡						‡	‡			‡	
Junk Mill	Part No.	41618	41621	41623	41626	41630	41635	41635	41635	41641	41641
	Weight	5	6	7	8	9	15	16	17	20	21
Round Nose Mill (60 ° Incl. Angle)	Part No.	41918	41921	41923	41926	41930	41935	41935	41935	41941	41941
	Weight	8	9	11	13	15	25	25	25	32	33
Taper Mill (30 ° Incl. Angle)	Part No.	—	—	—	—	41999	42000	42000	42000	42001	42001
	Weight	—	—	—	—	16	33	33	33	42	42
10" Fishing Neck for Above Mills	Part No.	—	—	—	—	42027	42028	42028	42028	42029	42029
Extra Charge	Weight	—	—	—	—	16	28	28	28	35	35
Fishing Neck OD – Inches		—	—	—	—	3-1/8	3-3/4	3-3/4	3-3/4	4-1/4	4-1/4

Mill Size (OD)		5-5/8 – 5-3/4	5-7/8 – 6	6-1/8 – 6-1/4	6-3/8 – 6-1/2	6-5/8 – 6-3/4	6-7/8 – 7	7-1/8 – 7-1/4	7-3/8 – 7-1/2	7-5/8 – 7-3/4	7-7/8 – 8
Top Connection – Pin		3-1/2 A.P.I. Reg.	3-1/2 A.P.I. Reg.	3-1/2 A.P.I. Reg.	3-1/2 A.P.I. Reg.	3-1/2 A.P.I. Reg.	3-1/2 A.P.I. Reg.	3-1/2 A.P.I. Reg.	4-1/2 A.P.I. Reg.	4-1/2 A.P.I. Reg.	4-1/2 A.P.I. Reg.
Catalog Standard ‡						‡			‡		
Junk Mill	Part No.	41641	41647	41647	41647	41653	41653	41653	41659	41659	41659
	Weight	22	25	26	27	31	32	33	39	40	41
Round Nose Mill (60 ° Incl. Angle)	Part No.	41941	41947	41947	41947	41953	41953	41953	41959	41959	41959
	Weight	34	39	38	39	49	50	51	79	80	81
Tapper Mill (30 ° Incl. Angle)	Part No.	42001	42002	42002	42002	42003	42003	42003	42004	42004	42004
	Weight	42	52	52	53	65	65	65	108	110	112
10" Fishing Neck for Above Mills	Part No.	42029	42029	42029	42029	42029	42029	42029	42030	42030	42030
Extra Charge	Weight	35	35	35	35	35	35	35	62	62	62
Fishing Neck OD – Inches		4-1/4	4-1/4	4-1/4	4-1/4	4-1/4	4-1/4	4-1/4	5-3/4	5-3/4	5-3/4

Mill Size (OD)		8-1/8 – 8-1/4	8-3/8 – 8-1/2	8-5/8 – 8-3/4	8-7/8 – 9	9-1/8 – 9-1/4	9-3/8 – 9-1/2	9-5/8 – 9-3/4	9-7/8 – 10	10-1/8 – 10-1/4	10-3/8 – 10-1/2
Top Connection – Pin		4-1/2 A.P.I. Reg.	4-1/2 A.P.I. Reg.	4-1/2 A.P.I. Reg.	4-1/2 A.P.I. Reg.	4-1/2 A.P.I. Reg.	4-1/2 A.P.I. Reg.	6-5/8 A.P.I. Reg.	6-5/8 A.P.I. Reg.	6-5/8 A.P.I. Reg.	6-5/8 A.P.I. Reg.
Catalog Standard ‡		‡			‡			‡			‡
Junk Mill	Part No.	41665	41665	41665	41671	41671	41671	41677	41677	41677	41683
	Weight	54	55	56	68	70	72	107	115	121	128
Round Nose Mill (60 ° Incl. Angle)	Part No.	41965	41965	41965	41971	41971	41971	41977	41977	41977	41983
	Weight	84	85	86	118	120	122	175	181	187	218
Taper Mill (30 ° Incl. Angle)	Part No.	42005	42005	42005	42006	42006	42006	42007	42007	42007	42008
	Weight	116	118	120	160	168	174	233	239	245	290
10" Fishing Neck for Above Mills	Part No.	42030	42030	42030	42030	42030	42030	42031	42031	42031	42031
Extra Charge	Weight	62	62	62	62	62	62	105	105	105	105
Fishing Neck OD – Inches		5-3/4	5-3/4	5-3/4	5-3/4	5-3/4	5-3/4	7-3/4	7-3/4	7-3/4	7-3/4

Mill Size (OD)		10-5/8 – 10-3/4	10-7/8 – 11	11-1/8 – 11-1/4	11-3/8 – 11-1/2	11-5/8 – 11-3/4	11-7/8 – 12	12-1/8 – 12-1/4	12-1/2 – 14	14-1/8 – 17-1/4	17-3/8 – Up
Top Connection – Pin		6-5/8 A.P.I. Reg.	6-5/8 A.P.I. Reg.	6-5/8 A.P.I. Reg.	6-5/8 A.P.I. Reg.	6-5/8 A.P.I. Reg.	6-5/8 A.P.I. Reg.	6-5/8 A.P.I. Reg.	6-5/8 A.P.I. Reg.	7-5/8 A.P.I. Reg.	7-5/8 A.P.I. Reg.
Catalog Standard ‡				‡			‡				
Junk Mill	Part No.	41683	41683	41689	41689	41695	41695	41695	41695	68807	152359
	Weight	134	139	143	149	155	162	168	174	—	—
Round Nose Mill (60 ° Incl. Angle)	Part No.	41983	41983	41989	41989	41989	41995	41995	41995	—	—
	Weight	220	226	229	235	241	280	284	288	—	—
Taper Mill (30 ° Incl. Angle)	Part No.	42008	42008	42009	42009	42009	42010	42010	42010	152517	152518
	Weight	296	302	298	304	310	370	376	382	—	—
10" Fishing Neck for Above Mills	Part No.	42031	42031	42031	42031	42031	42031	42031	42031	—	—
Extra Charge	Weight	105	105	105	105	105	105	105	105	—	—
Fishing Neck OD – Inches		7-3/4	7-3/4	7-3/4	7-3/4	7-3/4	7-3/4	7-3/4	7-3/4	—	—

How to Order

Specify:

(1) Name and part number of Mill
(2) O.D. of Mill
(3) Top connection, if other than standard
(4) If Fishing Neck is desired, order Mill and Fishing Neck by number

Recommended for Redressing Mills:

(1) Bowen Itcoloy
(2) Bowen Tinning Rod
(3) Bowen Brazing Flux

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* Denotes Manufacturing and Engineering facilities

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Lifting and Handling Solutions

Production Solutions

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Tubular and Corrosion Control Solutions

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